453-ICD-DAS/WSC

NETWORK AND MISSION SERVICES PROGRAMS

INTERFACE CONTROL DOCUMENT BETWEEN THE DEMAND ACCESS SYSTEM (DAS) AND THE WHITE SANDS COMPLEX (WSC)

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National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

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Preface

The purpose of this document is to provide the interface requirements between the Demand Access System (DAS) and the equipment implemented at the White Sands Ground Terminal (WSGT) and at the Guam Remote Ground Terminal (GRGT).

This document is under the configuration management of the Network and Mission Services Program Space Network (SN) Configuration Control Board (CCB).

This document may be updated by Documentation Control Notices (DCN) or revision.

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Change Information Page

List of Effective Pages	
Page Number	**Issue**
1-1/1-2 (blank)	Original
2-1/2-2 (blank)	Original
3-1 through 3-9/3-10 (blank)	Original
4-1 through 4-19/4-20 (blank)	Original
A-1 through A-5/A-6 (blank)	Original
AB-1 through AB-2	Original

Document History			
Document Number	**Status/Issue**	**Publication Date**	**CCR Number**
453-ICD-DAS/WSC	Original	15 February 2000	

TBR Listing

ID	Title/ Description	ICD Paragraph
TBR-1	Alert I/F TBR-1a: Physical I/F; DB-9F (sockets) connector at WSC TBR-1b: Physical I/F; DAS shall provide cable with a DB9M (pins) connector with thumbscrews	4.4.4

TBD Listing

ID	Title/ Description	ICD Paragraph
TBD-1	#, Size of circuits required at WSGT	4.7.2.1
TBD-2	#, Size of circuits required at GRGT	4.7.2.2
TBD-3	ECON to DAS I/F: TBD-3c: UDP/IP Addresses	4.3.7
TBD-4	Alert I/F: J#'s for point of demarcation	4.4.5
TBD-6	CDB I/F: TBD-6c: CDB IP addressees	4.2.4
TBD-7	CTFS I/F: TBD-7a: Rack/J#'s numbers for Freq Ref 'Demarcation Points' TBD-7b: Rack/J#'s numbers for Time Ref 'Demarcation Points' TBD-7c: Rack/J#'s numbers for 1 PPS Ref 'Demarcation Points'	4.5

DCN Control Sheet

DCN Number	Date/Time Group	Month/ Year	Section(s) Affected	Initials

Contents

FIGURES

TABLES

SECTION 1. INTRODUCTION

1.1 Purpose

The purpose of this document is to define the functional, performance, logical, electrical, and physical characteristics of the interface between the Demand Access System (DAS) and the White Sands Complex (WSC).

1.2 Scope

This document addresses all electrical and signal interfaces between DAS and the WSC equipment at White Sands, New Mexico, and Guam. It does not specifically address the local man-machine interfaces that are part of DAS, and used by on-site personnel. Rack space requirements are documented as part of the DAS Site Preparation and Installation Plan, 028-600031, and are not included here. DAS interfaces between DAS Customers and NASA Integrated Services Network (NISN) Closed Internet Protocol (IP) Operational Network (IOnet), and the SN Web Services Interface (SWSI) are documented in the Interface Control Document (ICD) between the DAS and DAS Customers, 453-ICD-DAS/Customers, and the ICD between the DAS and the SWSI, 453-ICD-DAS/SWSI, respectively.

SECTION 2. DOCUMENTS

2.1 General

The following documents are part of this ICD to the extent cited therein. The most recent version of these documents takes precedence. If there are conflicts between the listed documents and the requirements of this ICD, the requirements of this ICD take precedence.

2.1.1 Applicable Documents

Document Number	Document Title
036-140776	Hardware Design Document For The Third-Generation TDRSS MA Beamforming Subsystem
104-70	IRIG Specification
530-ICD-NCC-FDF/WSC	Interface Control Document between the Network Control Center/Flight Dynamics Facility and the White Sands Complex, Figure 9-1
LOR-TR2387	GDIS Operations Manual

2.1.2 Reference Documents

Document Number	Document Title
STDN 270.5	GSFC Specification for Electronic Equipment Racks
036-140773	TGBFS ICD
453-SRD-DAS	Demand Access System Systems Requirements Document
FC-PH0	Fibre Channel Physical Layer 0 Specification
FC-PH1	Fibre Channel Physical Layer 1 Specification
028-600031	DAS Site Preparation and Installation Plan
IEEE 754	IEEE Standard for Binary Floating Point Arithmetic

SECTION 3. INTERFACE DESCRIPTION

3.1 General

The interfaces between the WSC equipment and DAS include the following, and are described in the ensuing paragraphs. Section 4 provides the corresponding requirements.

- the Element Multiplexer Correlator (EMC) to DAS interface,
- the EMC Controller (ECON) to DAS interface,
- the DAS to White Sands Ground Terminal (WSGT) alert interface,
- the Common Timing and Frequency System (CTFS) to DAS interface,
- the GRGT Data Interface System (GDIS) to DAS interface, and
- the WSC power to DAS interface.

Figures 3-1 and 3-2 show the DAS external interfaces at WSGT and GRGT, respectively.

3.2 EMC to DAS Interface

3.2.1 Local and Remote EMC Connectivity Overview

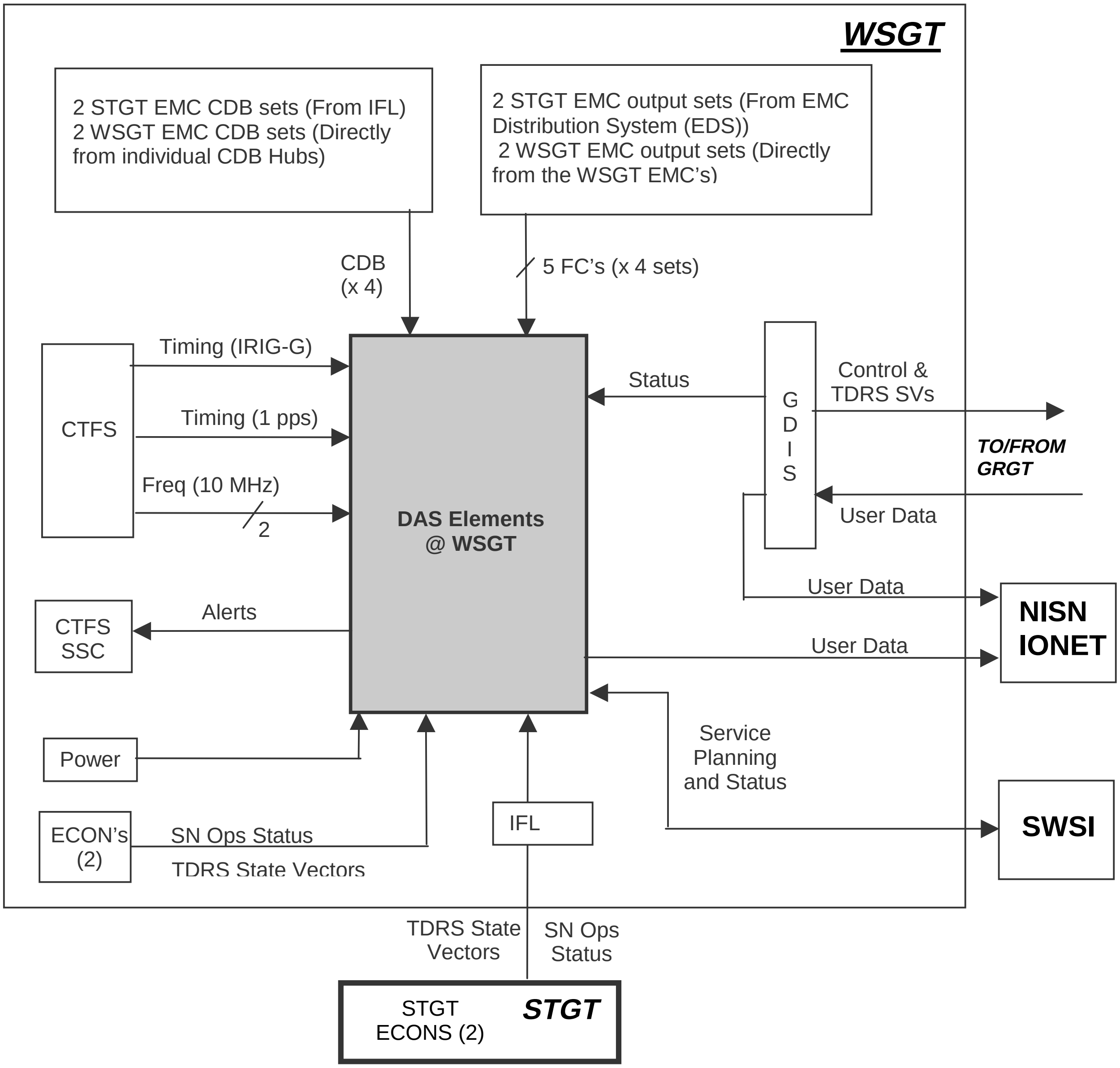
Figure 3-3 depicts the interface between the EMC and the DAS . The EMC distribution system at WSGT provides the EMC Fibre Channel (FC) outputs to DAS for the Second Tracking and Data Relay Satellite (TDRS) System (TDRSS) Ground Terminal (STGT) EMC FC's only. The Common Data Broadcast (CDB) data is distributed via WSGT hubs for STGT EMC's and WSGT EMC's.

3.2.2 MA Element Data

The Multiple Access (MA) Element Data (ELD) interface consists of multiple sets of five copper cables or fibers. Each set of five cables represents a digitized and multiplexed version of the thirty TDRS MA phased array antenna element signals. The cables, number one through five, each contain six elements of the thirty element array, 1-6 on the first cable, 7-12 on the second cable, and so on. Element numbering is as designated in the Hardware Design Document for the Third Generation Beamforming Subsystem, 036-140776.

The MA Beamforming Equipment (MABE) receives the Radio Frequency (RF) downlink of each element signal and downconverts each to Intermediate Frequency (IF). The IF is then subsampled and split into quadrature terms to yield thirty sets of 8-bits I and 8-bits Q data. The subsampling is used to further downconvert the IF and conjugate the spectrum of each element signal. The sampling rate is 8.5 MHz on each I and Q, providing a bandwidth of 8.5 MHz for

Figure 3-1: DAS External Interfaces at WSGT



each element signal. A 4.25 MHz test tone is uniformly injected on each element for BIT purposes.

The EMC accepts the digital data from each of the thirty channels. The I and Q samples for each element are concatenated to form a 16-bit word, and are time multiplexed in groups of six at a rate of 51 Msps. Each group of six (there are five sets) is encoded and serialized as specified by the FC specification (FC-PH0 and FC-PH1). The framing used for the FC packets is a custom implementation that adds one 16-bit word of overhead for every 24 words of data. This strict ratio is necessary to balance the 51 Msps rate of the time-multiplexed element data and the native 53.125 Msps rate of FC. The data and overhead are arranged into a frame structure, which is 200

16-bit words in length, including 8 16-bit overhead words. FC uses special 32-bit characters for link control, so four FC words are added: a start of frame marker, and end of frame marker, a cyclic redundancy check word, and a special idle character. The idle character is placed in the center of each frame and is used in each Independent Beamforming Unit (IBU) to resynchronize the five channels. Each channel passes real-time data continuously, so there is no room for additional overhead. The EMC synchronizes each of the five channels to within one 53.125 MHz clock cycle, and transmits up to eleven copies of the complete element bus.

Figure 3-2: DAS External Interfaces at GRGT

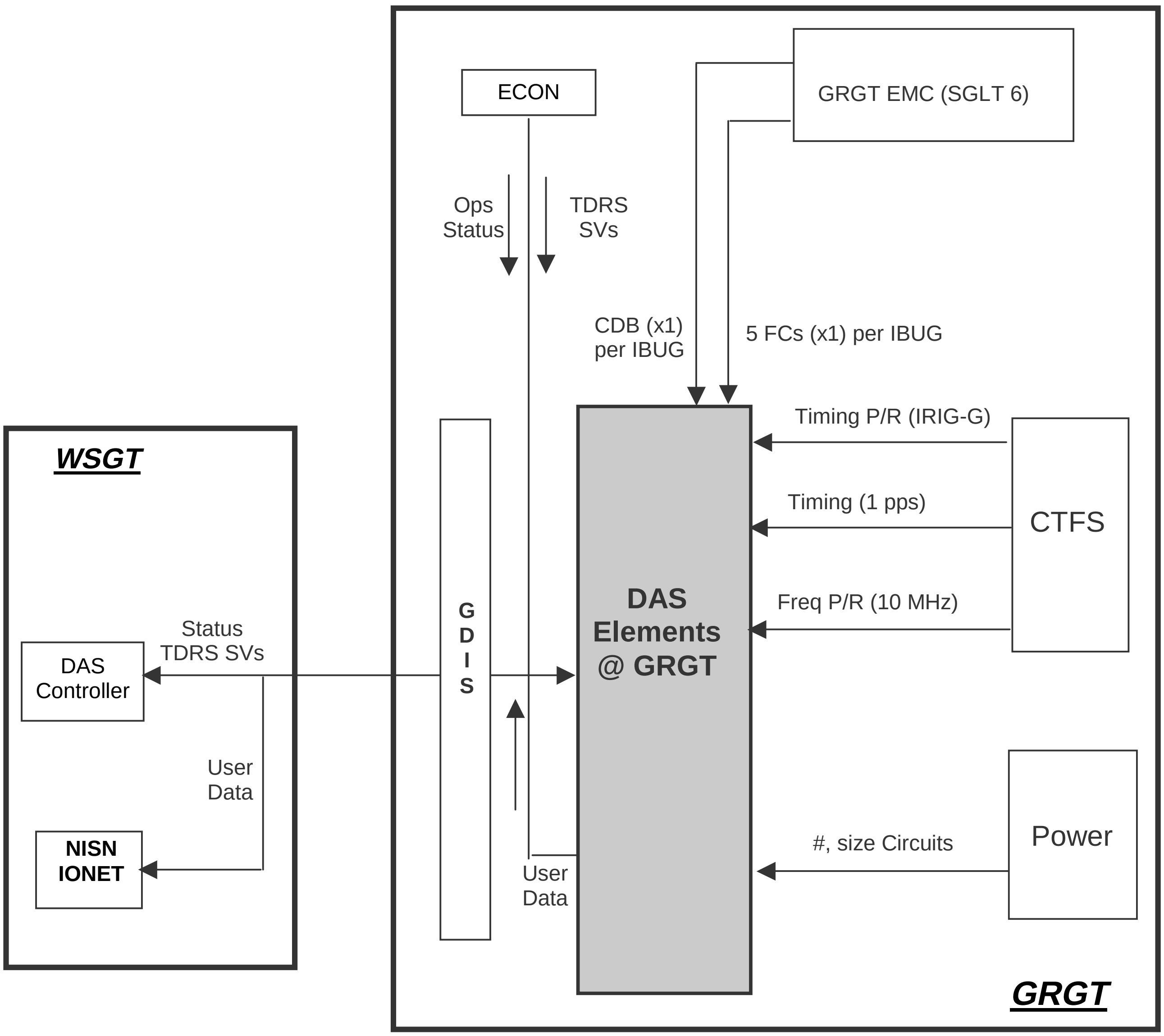
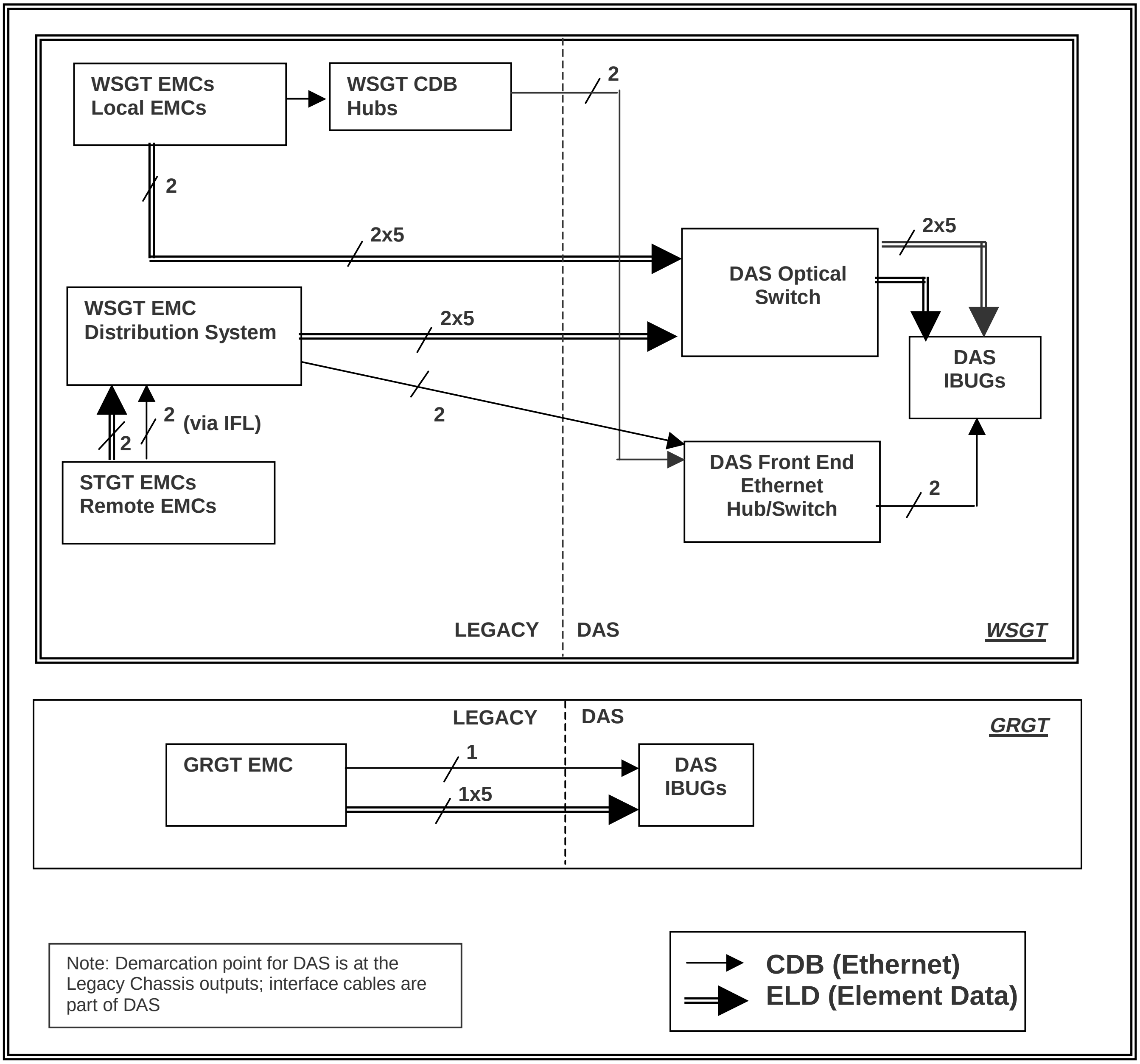


Figure 3-3: EMC to DAS Interface



3.2.3 Common Data Broadcast

3.2.3.1 Inverted Covariance Matrix

The inverted version of the 30x30 element covariance matrix is included in the message. Each position in the matrix is complex except for the main diagonal; both the real and imaginary components are stored in 32-bit IEEE floating point format. The covariance matrix is hermitian, and each element of the upper triangle is obtained by generating the cross-correlation of 16384 complex samples. The main diagonal is the auto-correlation, and represent the power present in each element signal. All thirty elements are sampled during the same time interval in order to ensure a constant interference environment. Since the inverted matrix is also hermitian, the matrix inversion is performed using the upper triangle to populate the rest of the matrix. There is no rounding or clipping during the covariance matrix generation process. The inverted matrix is computed using double precision (64-bit) IEEE floating point numbers, which are rounded to 32-bits prior to transmission.

3.2.3.2 Noise Vector Description

The noise vector is a 30-element vector derived from the main diagonal elements of the covariance matrix. Each number is therefore a real number, and is stored in 32-bit IEEE floating point format. It physically represents the power of each element signal, and is computed by performing an auto-correlation of 16384 complex samples obtained from each element. No rounding, clipping or truncation results during the correlation.

3.2.3.3 Calibration Vector Description

The calibration vector is a 30-element vector computed in the MABE and passed through the EMC to the DAS. Each element in the vector is complex, where the real and imaginary components are represented in 32-bit IEEE floating point format. The calibration vector is obtained by measuring from each element signal path the amplitude and residual phase of a reference signal that has been coherently downconverted. The calibration vector itself is generated by performing an element-by-element division of the measured transfer function of that element's signal path by the computed pointing vector, which directs the array to the source of the reference signal. The division provides an estimate of the transfer function of each element signal path from the array elements to the point of measurement in the MABE, and allows for phase and amplitude correction of the non-uniform downlink and subsequent signal processing.

3.2.3.4 Element Status Description

The element status word utilizes the 30 Least Significant Bits (LSB’s) of the 32 bits contained in the status word. A "valid" state is indicated by a one (1), an "invalid" state is indicted by a zero (0). The element status word is the composite of the known element status (provided by operator to the EMC), and measured status as derived from: parity checks on the I and Q data words from the Analog/Digital Quad Splitter (ADQS), 4.25 MHz clock transitions from the ADQS, EMC hardware status as derived from on-line and extended BIT’s, and data derived from the signal processing performed on each element. The latter piece of element status is obtained during the generation of the covariance matrix, when an estimate of the signal-plus-noise power environment is obtained (elements whose power estimate drift beyond specified limits are considered failed).

3.2.3.5 Synchronization Command Description

In addition to the signal processing data that is passed over the CDB interface, a sync message is used to indicate to the DAS that the EMC resynchronized the node boards, an activity which requires each beamformer to resynchronize its five discrete FC's. A node resynchronization will occur for the following reasons: EMC power-up or reset, the failure of a clock source (a prime and redundant clock are provided from the MABE), or the hot-insertion of a node card. Additionally, the EMC will resynchronize the nodes before and after performing an off-line BIT, and before and after entering the data generator mode of operation. A resync can also be invoked from the Front Panel Display (FPD).

3.3 ECON to DAS Interface

Each of the five ECON's that support the five TDRSS operational EMC's provide two types of DAS status: (1) TDRS State Vectors (SV's) and (2) SN operational status.

Note that this is not the EMC CDB, which is provided directly from an EMC and not from an ECON. Each ECON provides the SV and status data over the DAS control and status network as shown in Figure 3-4. The two STGT ECON interfaces to DAS are provided via the STGT – WSGT Interfacility Link (IFL).

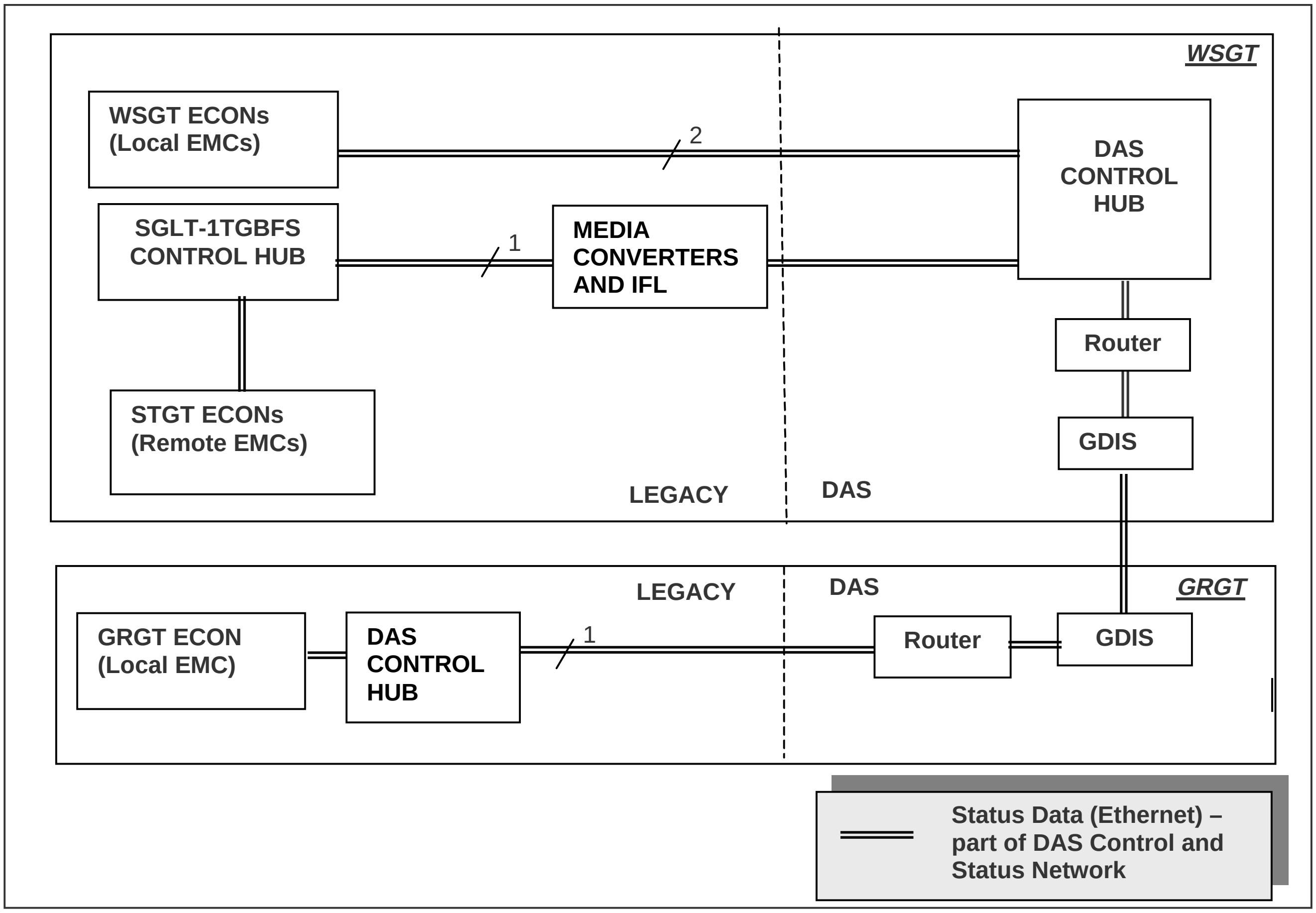
3.3.1 TDRS State Vector Data

The Flight Dynamics Facility (FDF) uses tracking data to compute satellite orbit products. One type of orbit product is predictive orbit information. Predictive orbit information is used to compute spacecraft acquisition data. This data takes the form of Improved Interrange Vectors (IIRV's). IIRV's are generally referred to as SV's.

FDF applies a state vector propagator to the "initial solution" state vectors. This propagator produces a state vector updates spaced at one-hour intervals. Every day, a forty-eight (48) hour set of TDRS state vector updates/solutions is provided to WSC via the Network Control Center (NCC).

The SV transmission is received by the Data Interface System (DIS) Automated Data Processing Equipment (ADPE's) at STGT and WSGT, which then forwards the SV's for all the TDRS spacecraft to each of the Executive (EXEC) ADPE's. The prime EXEC ADPE in each Space-to-Ground Link Terminal (SGLT) will then forward only the first vector in each SV set for the TDRS being supported on that SGLT, to the respective ECON associated with that SGLT. A connection from both of the EXEC ADPE's in each SGLT to ECON allows transmission of the SV's regardless of which ADPE is prime. This is repeated on each SGLT that supports an ECON.

Figure 3-4: ECON to DAS Interface



3.3.2 SN Operational Data

In addition to TDRS SV information, MA return operational equipment health and status information will be provided to DAS on a per MA capable SGLT basis via the ECON associated with that SGLT. This information includes, but is not limited to TDRS MA array element status, EMC hardware and firmware status, calibration vector interface status, etc. The DAS will use this information in order to properly support MA Customer return services and to inform operators of possible fault conditions present in the TDRS MA return element data recovery and distribution system.

3.4 DAS to WSGT Alert Interface

This interface is similar in purpose and functionality to the existing ECON alert interface with the MA Subsystem Controller (SSC). For DAS, the interface is with the CTFS SSC at WSGT. The alert status is a “Go/No-Go” type of message and will alert an operator of a potential problem. The operator will then access the DAS Local Control Monitor (LCM) if additional data is needed. The WSC CTFS SSC will poll the DAS Controller (DASCON) for the alert status.

3.5 CTFS to DAS Interface

3.5.1 Frequency Reference

The CTFS at WSGT and GRGT will provide an ultra-stable and highly reliable 10 MHz reference signal based on the existing Cesium standard and disciplined oscillator. Two-for-one redundancy will be provided.

3.5.2 Time of Year Timing Reference

The CTFS at WSGT and GRGT will provide an Inter-Range Instrumentation Group (IRIG)-G time standard.

3.5.3 1 pps Timing Reference

The CTFS at WSGT and GRGT will provide accurate 1 Pulse Per Second (pps) time tics.

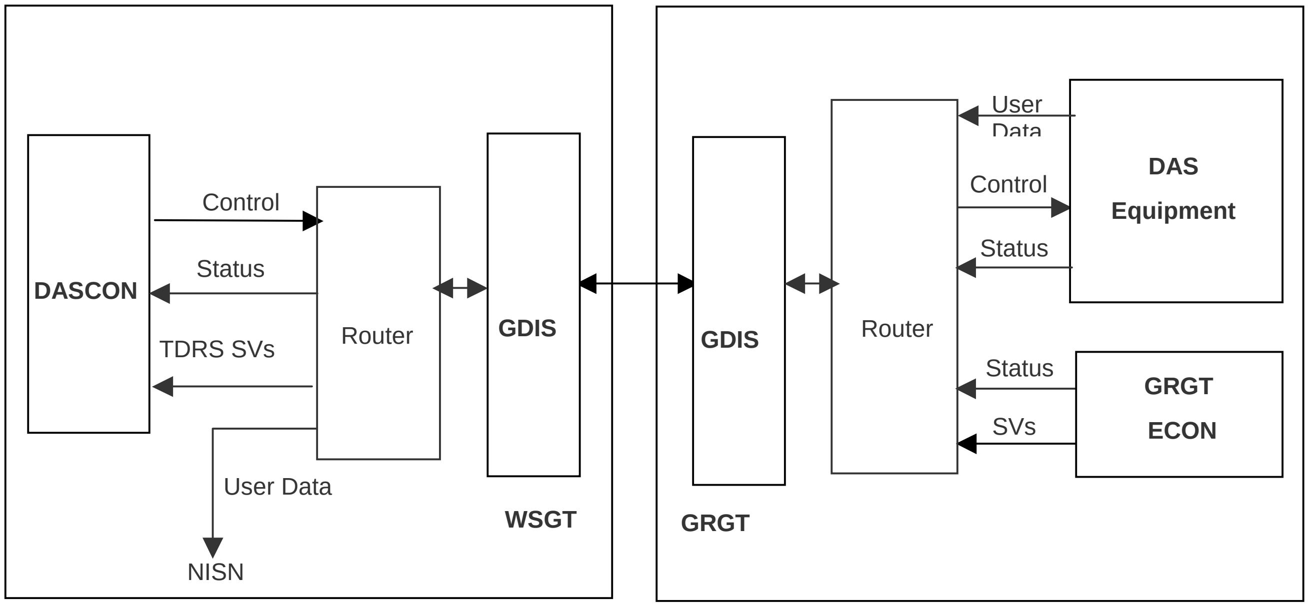
3.6 GDIS to DAS Interface

Figure 3-5 depicts the interface between the GDIS and the DAS. Note that the TDRS SV's are shown separately from the DASCON configuration/control channel, but will be physically part of the same channel stream. Routers and conversion to RS-422 are required. The link between the GRGT DAS equipment and the WSGT DAS equipment will be routed via a single link over GDIS. The DAS interface to ECON, user data, and TDRS SV's will be multiplexed onto this link.

3.7 WSC Power to DAS Interface

110 V power is provided to DAS at WSGT and GRGT. The number and size of circuits are specified in Paragraph 4.7. Additional grounding requirements are specified in the DAS SRD, 453-SRD-DAS, and in the GSFC Specification for Electronic Equipment, STDN 270.5.

Figure 3-5: GDIS to DAS Interface



SECTION 4. INTERFACE REQUIREMENTS

4.1 General

Section 4 specifies the requirements for the following six (6) interfaces between the DAS and the WSC:

- the EMC to DAS interface,
- the ECON to DAS interface,
- the DAS to WSGT alert interface,
- the CTFS to DAS interface,
- the GDIS to DAS interface, and
- the WSC power to DAS interface.

4.2 EMC to DAS Interface

4.2.1 EMC to DAS Interface Types

a. WSGT shall provide two types of EMC outputs (i.e., ELD and CDB) from each of the four WSC SGLT's to DAS.
b. GRGT shall provide two types of EMC outputs (i.e., ELD and CDB) from the GRGT EMC to DAS.

4.2.2 MA Element Data Interface

4.2.2.1 Points of Demarcation

4.2.2.1.1 SGLT-1 and -2 Points of Demarcation

a. The demarcation points for the ELD interface for SGLT-1 and -2 shall be at the output of the EMC Distribution System (EDS) FC switches.
b. The DAS port assignments shall be as defined in Table 4-1.

4.2.2.1.2 SGLT-4 and -5 Points of Demarcation

a. The demarcation points for the ELD interface for SGLT-4 and -5 shall be at the output of the EMC FC switches.
b. The DAS port assignments shall be as defined in Table 4-2.

Table 4-1: SGLT-1 and -2 Points of Demarcation

	SGLT	Element Group	Rack #	Switch and Port
1.	1	1	7151	A8A1D3
2.	1	2	7151	A8A1D4
3.	1	3	7151	A8A2D3
4.	1	4	7151	A8A2D4
5.	1	5	7151	A8A2D5
6.	2	1	7151	A8A1D5
7.	2	2	7151	A8A1D6
8.	2	3	7151	A8A2D6
9.	2	4	7151	A8A2D7
10.	2	5	7151	A8A2D8

Table 4-2. SGLT-4 and -5 Points of Demarcation

	SGLT	Element Group	Rack #	Switch and Port
1.	4	1	1027	A3A20B3D1
2.	4	2	1027	A3A20B3D3
3.	4	3	1027	A3A20B3D6
4.	4	4	1027	A3A20B2D1
5.	4	5	1027	A3A20B2D3
6.	5	1	1227	A3A20B3D1
7.	5	2	1227	A3A20B3D3
8.	5	3	1227	A3A20B3D6
9.	5	4	1227	A3A20B2D1
10.	5	5	1227	A3A20B2D3

4.2.2.1.3 SGLT-6 Points of Demarcation

a. The demarcation points for the ELD interface for SGLT-6 shall be at the output of the EMC FC switches.
b. The DAS port assignments shall be as defined in Table 4-3.

Table 4-3: SGLT-6 Points of Demarcation

	SGLT	Element Group	Rack #	Switch and Port
1.	6	1	1426	A1A20B3C1
2.	6	2	1426	A1A20B3C3
3.	6	3	1426	A1A20B3C6
4.	6	4	1426	A1A20B2C1
5.	6	5	1426	A1A20B2C3

4.2.2.2 Signal Characteristics.

a. The optical port cables shall be part of DAS.
b. The optical cables shall connect to the demarcation point in Paragraph 4.2.2.1.
c. The optical cables shall have the characteristics cited in Table 4-4.

Table 4-4: Optic Port Cable

	Physical Interface	Value
1.	Connector	Simplex SC
2.	Media	50 μm multimode fiber
3.	Maximum Fiber Length	300 meters
4.	Wavelength	770 to 860 nm
5.	Power	-16 to 0 dBm
6.	Maximum Data Run Length	10 bits

4.2.2.3 Signal Data Format

a. Signal data shall use FC Physical (FC-PH) layer zero (0)-and one (l)-compliant formats at 1.0625 Gbps.
b. Signal data shall use layer two (2)-compliant formats using the structure in Figure 4-1.

Figure 4-1: Fibre Channel Frame Structure

SOF	SOF	D1	D2	-	D95	IDLE	IDLE	D96	D97	-	D191	CRC	CRC	EOF	EOF

192 Data Words (16 bits)
Total Frame Length = 200 words

Where:	-	Frame requires eight words of overhead
	-	SOF 32-bit Start of Frame Connect Class I (SOF_c1)
	-	CRC 32-bit Cyclic Redundancy Check
	-	CRC only applies to Data Words of the Frame
	-	EOF = 32-bit End of Frame (EOF_N)
	-	Idle: Negative Running Disparity only

4.2.2.4 Frame Format

The EMC shall provide signal data using the 16-bit format in Table 4-5.

4.2.2.5 Signal Bandwidth

The EMC shall provide five (5) individual signals each at 1.0625 Gbps per FC.

Table 4-5. 16-bit Format within a Frame

	I	Q
Data bits	**0 to 7**	**8 to 15**
	LSB → MSB	**LSB → MSB**
Encoded bits: (8B/10B encoded bits)	**0 to 9**	**10 to 19**

4.2.2.6 Channel Assignment

a. Element group 1 shall contain data for element channels 1 to 6.
b. Element group 2 shall contain data for element channels 7 to 12
c. Element group 3 shall contain data for element channels 13 to 18
d. Element group 4 shall contain data for element channels 19 to 24
e. Element group 5 shall contain data for element channels 25 to 30.

4.2.2.7 MA Array Data Timing Skew

The maximum timing skew between any of the five 1.0625 Gbps channels that comprise the element data shall be less than 1.5 μsec.

4.2.3 Common Data Broadcast Interface

4.2.3.1 CDB Contents

The CDB traffic shall consist of the following message types:
a. Beamforming data message, and
b. Data synchronization command.

4.2.3.2 CDB Protocol

The CDB shall utilize User Datagram Protocol/ Internet Protocol (UDP/IP) for the CDB data interface protocol.

4.2.3.3 CDB Periodicity

a. The EMC shall transmit the beamforming data message nominally once per second.
b. The EMC shall transmit the data synchronization command as necessary when the EMC needs to resynchronize timing.

4.2.3.4 Message Format

4.2.3.4.1 Beamforming Data Message

a. The beamforming data message shall contain the inverse covariance matrix, calibration vector, noise vector element status, and TDRSS flight designator.

b. The beamforming data message shall be in the format specified in Table 4-6.

Table 4-6: Beamforming Data Message

Field Length (Bytes)	Bits required per entry	Format type	Value /Range	Description
4	32	Enumeration	0	Message type
7200	64	Complex float Per IEEE 754	-	Inverse covariance matrix $CORR_{1,1,}$I,Q $CORR_{1,2,}$I.Q . . . $CORR_{30,30,}$I,Q
240	64	Complex float Per IEEE 754	-	Calibration Vector Element 1 ,Q Element 2 I,Q . . . Element 30 I,Q
120	32	Float Per IEEE 754	-	Noise Vector Element 1 Element 2 . . . Element 30
4	1	Binary	0 – 1 where 0 = faulted 1 = good	Element Status LSB-elem. 1 MSB-elem. 30 Bits 31, 32 are spares
2	16	Enumeration		TDRS ID
NOTE: all data is 32-bit big endian.				

4.2.3.4.2 Data Synchronization Command

The data synchronization command shall be in the format specified in Table 4-7.

Table 4-7: Data Synchronization Command Format

Field Length (Bytes)	Bits required per entry	Format type	Value /Range	Description
4	32	Enumeration	1	Message Type
4	32	Enumeration	0	Synch Command
NOTE: all data is 32-bit big endian.				

4.2.3.5 CDB Physical Interface

a. The CDB interface shall be via a 10BaseT Ethernet connection.

b. The WSC CDB source shall be an RJ-45 modular jack.

c. The pin-out characteristics shall be as specified in Table 4-8.

Table 4-8: CDB Physical Interface

Function	Position
TX-	2
TX+	1
Not used	4
Not used	5
Not used	7
Not used	8
RX+	3
RX-	6

4.2.3.6 CDB Points of Demarcation

The demarcation points for the CDB interface shall be as defined in Table 4-9.

Table 4-9: CDB Demarcation Points

	SGLT	Rack-Chassis	Port
1.	1	7151-A7	J7
2.	2	7151-A7	J8
3.	4	1027-A3A21	J3X
4.	5	1227-A3A21	J3X
5.	6	1523- A2A21	J4X

4.2.4 UDP/IP Addresses

The UDP/IP addresses shall be TBD-6c.

4.3 ECON to DAS Interface

SN status is provided by the five ECON’s that support the five operational EMC’s. Each ECON provides this status data over the DAS control and status network. The two STGT ECON interfaces to DAS are transported between sites via the STGT – WSGT IFL.

4.3.1 Types of Messages

The ECON to DAS interface traffic shall consist of the following message types:

a. TDRS SV's, and
b. SN operational status data.

4.3.2 Message Protocol

a. The ECON to DASCON interface shall be a Transmission Control Protocol (TCP)/IP socket with custom formatted messages.
b. All messages shall have a message type as part of its header information.

4.3.3 Message Periodicity

4.3.3.1 TDRS SV's

a. The TDRS SV's shall be transmitted to DAS by the ECON immediately upon receipt from the EXEC ADPE.
b. The TDRS SV's shall be provided by the ECON when requested by DAS via a SV request.
c. DASCON shall alert the TOCC, via a "Go/No Go" alert through the CTFS SSC interface, when a TDRS SV transmission needs to be manually initiated from the EXEC ADPE.

4.3.3.2 SN Operational Status Data

The ECON's shall provide SN status data at one second intervals.

4.3.4 Message Formats

4.3.4.1 TDRS SV's

The TDRS SV message shall be formatted as shown in Table 4-10.

4.3.4.2 SN Operational Status Data

The SN status message shall be formatted as shown in Table 4-11.

4.3.5 Physical Interface

a. The ECON to DAS interface shall be via 10BaseT Ethernet connection.
b. The WSC source shall be an RJ-45 modular jack
c. The pin-out characteristics shall be as specified in Table 4-12.

Table 4-10: ECON TDRS State Vector Message

Field Length Bytes	Bits Req.	Format/ Type	Value/ Range	Bit Num./ Units	Description
4	4	ENUM. Type	0	0-3	Report Type: 0 - TDRS State Vector Message 1 - ECON Status Report
	28	BIN	N/A	4-31	Spares
4	3	ENUM. Type	1-7	0-2	TDRS ID
	29	BIN	N/A	4-31	Spares
4	32	Long		0-31	GMT Number of seconds since 1/1/70
8	64	Double Precision (float per IEEE 754)		0-63	X Coordinate (km)
8	64	Double Precision (float per IEEE 754)		0-63	Y Coordinate (km)
8	64	Double Precision (float per IEEE 754)		0-63	Z Coordinate (km)
8	64	Double Precision (float per IEEE 754)		0-63	X Velocity (km/s)
8	64	Double Precision (float per IEEE 754)		0-63	Y Velocity (km/s)
8	64	Double Precision (float per IEEE 754)		0-63	Z Velocity (km/s)

4.3.6 Points of Demarcation

a. The demarcation points for the ECON to DAS interface shall be as are defined in Table 4-13.

b. The SGLT-1 and -2 interfaces shall be provided over the IFL with the demarcation point residing at WSGT.

c. The SGLT-4, -5, and -6 interfaces shall be at the TGBFS control and status hub in each SGLT.

4.3.7 UDP/IP Addresses

The UDP/IP addresses shall be TBD-3c.

Table 4-11: ECON Status Report Message

Field Length Bytes	Bits Req.	Format/ Type	Value/ Range	Bit Num./ Units	Description
4	4	ENUM. TYPE	1	0-3	Report Type: 0 - TDRS State Vector Message 1 - ECON Status Report
	28	BIN	N/A	4-31	Spares
4	2	ENUM. TYPE	0 to 5	0-1	Operating Mode
	2	ENUM TYPE		2-3	Calibration Mode
	1			4	MABE HDLC A Int Status
	1			5	MABE HDLC B Int Status
	1			6	EMC Local/Remote Status
	8			7-14	TDRS ID
	8	ENUM TYPE		15-22	PN Code
	1			23	PN Status
	8	BIN	N/A	24-31	Spares
4	1	BIN		0	Clock A Int Status
	1	BIN		1	Clock B Int Status
	1	BIN		2	Local Clock Status
	29	BIN	N/A	3-31	Spares
4	30	BIN		0-29	Global Element Array
	2			30-31	EMC Alarm
4	13	BIN		 0 1 2 3 4 5 6 7 8 9 10 11 12	Hardware Status (0 - Fault/ 1 - No Fault) Node 1 Node 2 Node 3 Node 4 Node 5 Clock and Sync Power Supply NTS 1 NTS 2 CP Sharc PMC HDLC CDB
	5	BIN		 13 14 15 16 17	Node Card (1 – Present/0 – Not Present) Node 1 Node 2 Node 3 Node 4 Node 5
	14	BIN		18-31	Spares

Table 4-12: ECON to DAS Physical Interface

Function	Position
TX-	2
TX+	1
Not used	4
Not used	5
Not used	7
Not used	8
RX+	3
RX-	6

Table 4-13: ECON to DAS Interface Points of Demarcation

	SGLT	Rack-Chassis	Port
1.	1	7104W-A34	B3 10base-T
2.	2	7104W-A34	B3 10base-T
3.	4	1027W-A3A23	Demand Access Processor (DAP)
4.	5	1227W-A3A23	DAP
5.	6	1523-A2A23	DAP

4.4 DAS to WSGT Alert Interface

The DAS alert interface is with the CTFS SSC at WSGT. This interface is similar in purpose and functionality to the existing ECON alert interface with the MA SSC. The alert status is a “Go/No-Go” type of message and will alert an operator of a potential problem. The operator will then access the DAS LCM if additional data is needed. WSC polls the DASCON for the alert status.

4.4.1 Message Content

4.4.1.1 Status Request

a. The status request message shall be sent from the prime CTFS SSC to DAS.
b. The message shall consist of five bytes as specified in Table 4-14.

Table 4-14: Status Request Message Format

Byte Order	Bits	Range (Hex)	Range (ASCII)	Description
1,2	15:0	[5353]	‘SS’	Mnemonic
3,4	15:0	[0004]	[4]	Message Length
5	7:0	[24]	[‘$’]	End Marker

4.4.1.2 Status Response

a. The status response message shall be transmitted from DAS to the CTFS SSC requesting it.

b. The message format shall be as specified in Table 4-15.

c. Upon receipt of the status request, DAS shall complete its transmission of the status response in < 500 msec.

Table 4-15: Status Response Message Format

Byte Order	Bits	Range (Hex)	Range (ASCII)	Description
1,2	15:0	[5353]	‘SS’	Mnemonic
3,4	15:0	[000e]	[14]	Message Length
5,6	15:0	[00, 01]	[0, 1]	Status 0=Fail 1=Pass
7-13	15:0	[00, ff]	[0, 255]	Filler
14	7, 0	[24]	[‘$’]	End Marker

4.4.2 Message Protocol

The interface shall be via a serial interface using the protocol in Table 4-16.

Table 4-16: Alert Message Protocol

a.	Baud Rate	19.2k
b.	Data Bits	8
c.	Parity	Even
d.	Start Bits	1
e.	Stop Bits	1

4.4.3 Message Periodicity

The prime CTFS SSC will request status from DAS once per second.

4.4.4 Physical Interface

a. DAS shall interface with the prime and redundant CTFS SSC’s at WSGT via RS-422 interfaces.

b. WSC shall provide a physical interface consisting of a DB-9F (sockets) connector (TBR-1a).

c. DAS shall provide an interface cable with a DB9M (pins) connector (TBR-1b) with thumbscrews.

d. The pin assignments shall be as specified in Table 4-17.

e. Any signal loop-backs that are required shall be installed at the connectors interfacing to the DAS and WSC sources.

Table 4-17: Status Interface Pin Assignments

Pin	Definition	Signal Direction
1	TX+	DAS → SSC
2	TX-	DAS → SSC
3	RX+	DAS ← SSC
4	RX-	DAS ← SSC

4.4.5 Points of Demarcation

The points of demarcation for the alert interface shall be at the input/output panel of the CTFS racks containing the CTFS SSC's as defined in Table 4-18.

Table 4-18: Alert Interface Points of Demarcation

	SSC	Rack	J#
a.	A	1057	TBD-4
b.	B	1059	TBD-4

4.5 CTFS to DAS Interface

4.5.1 Frequency Reference

4.5.1.1 Quantity

The CTFS shall provide a prime and redundant frequency reference source at both WSGT and GRGT.

4.5.1.2 Frequency Reference Signal Characteristics

The frequency reference characteristics as seen at the point of demarcation shall be as specified in Table 4-19.

4.5.1.3 Frequency Reference Points of Demarcation

The CTFS shall provide a TRB female connector at the locations specified in Table 4-20.

4.5.2 CTFS Time Reference Requirements

4.5.2.1 Quantity

The CTFS shall provide one IRIG-G modulated time code signal as the timing reference source at WSGT and GRGT.

Table 4-18: Frequency Reference Signal Characteristics

	Parameter	Characteristic
a.	Frequency	10 MHz
b.	Amplitude	+13dBm (1.38Vrms)
c.	Output Impedance	95 ohms, balanced
d.	Frequency Accuracy	Within ±1.0 x 10^{-10}
e.	Short-term Frequency Stability	< 1 x 10^{-}" for averaging time τ, 1 sec < τ <100 sec
f.	Long-term Frequency Stability	Within ±1 x10^{-10}
g.	SSB Phase Noise in 1 Hz Bandwidth	<-70 dBc at 10^{-1} offset <-95 dBc at 10^{0} Hz offset <-110 dBc at 10^{1} Hz offset <-115 dBc at 10^{2} Hz offset <-130 dBc at 10^{3} Hz offset
h.	Spurious Outputs (any spur)	<-57 dBc
i.	Harmonic Outputs (any harmonic)	<-37 dBc

Table 4-20: Frequency Reference Points of Demarcation

	Site	A/B	Rack	J#
a.	WSGT	A	TBD-7a	TBD-7a
b.	WSGT	B	TBD-7a	TBD-7a
c.	GRGT	A	1451	TBD-7a
d.	GRGT	B	1453	TBD-7a

4.5.2.2 Time Reference Accuracy

The time reference shall have an accuracy of ±1 microsecond of United States Naval Observatory (USNO) Master Clock Universal Time Coordinated (UTC).

4.5.2.3 Time Reference Signal Characteristics

The timing reference signal shall be an IRIG-G modulated serial time code conforming to IRIG Specification, 104-70, with the additional characteristics in Table 4-21.

Table 4-21: Time Reference Signal Characteristics

	Parameter	Characteristic
a.	Voltage Level	0.5 volts RMS to 1.0 volts RMS (0.71 volts RMS nominal)
b.	Mark-to-space modulation ratio	3 to 1
c.	Output impedance	50 ohm, unbalanced

4.5.2.4 Time Reference Points of Demarcation

The CTFS shall provide a TNC female connector at the locations specified in Table 4-22.

Table 4-22: Time Reference Points of Demarcation

	Site	Rack	J#
a.	WSGT	TBD-7b	TBD-7b
b.	GRGT	TBD-7b	TBD-7b

4.5.3 CTFS 1 pps Requirements

4.5.3.1 1 pps Quantity

The CTFS shall provide one 1 pps timing reference source at WSGT and GRGT.

4.5.3.2 1 pps Accuracy

The time reference shall have an accuracy of ±1 microsecond.

4.5.3.3 1 pps Signal Characteristics

The timing reference signal shall be a modulated carrier with the characteristics in Table 4-23.

Table 4-23: 1 pps Time Reference Signal Characteristics

	Parameter	Characteristic
a.	Voltage Level	In accordance with EIA-422-A (0-5v)
b.	Output impedance	In accordance with EIA-422-A

4.5.3.4 1 pps Points of Demarcation

The CTFS shall provide a female three-lug connector (Ex. Trompeter BJ-79C) at the input/output panel of the racks specified in Table 4-24.

Table 4-24: 1 pps Points of Demarcation

	Site	Rack	J#
a.	WSGT	TBD-7c	TBD-7c
b.	GRGT	TBD-7c	TBD-7c

4.6 GDIS to DAS Interface

4.6.1 WSGT GDIS to DAS Interface

4.6.1.1 Points of demarcation

The points of demarcation between DAS and GDIS at WSGT shall be at the patch panels located in rack 1446.

4.6.1.2 Physical Interface

a. DAS shall interface with the GDIS via an RS-422/449 interface.

b. The DAS router shall be configured as a Data Terminal Equipment (DTE) device and the GDIS configured as the Data Communications Equipment (DCE) device.

c. DAS shall provide interface cables with male three-lug TRB style connectors.

d. The signal names, directions and connector locations shall be as specified in Table 4-25.

Table 4-25: WSGT GDIS to DAS Interface

	RS-449 Signal Name	Direction	WSGT GDIS Port	Connector
a.	RX Data (RD)	GDIS $\rightarrow$ DAS	OTU-6A	1446-A7J35
b.	RX Timing (RT)	GDIS $\rightarrow$ DAS	OTU-6A	1446-A7J36
c.	Send Timing (ST)	GDIS $\rightarrow$ DAS	OTU-6B	1446-A8J63
d.	Send Data (SD)	GDIS $\leftarrow$ DAS	ITU-4A	1446-A1J7
e.	TX Timing (TT)	GDIS $\leftarrow$ DAS	ITU-4A	1446-A1J8

4.6.1.3 WSGT GDIS Port Configuration

4.6.1.3.1 Input Port

The WSGT GDIS input port specified in Table 4-25, ITU-4A, shall be configured as specified in Table 4-26. The parameters are defined in the GDIS Operations Manual, LOR-TR2387.

Table 4-26: WSGT GDIS Input Port Configuration

Parameter	Value
Channel	
Enabled	Enabled
Block Mode	Disabled
Local Control	Disabled
PN Test	Disabled
Invert Data	Disabled
Invert Clock	Disabled
Reverse Clock	Disabled
Time Out	Disabled
Time Tag	Disabled
Modify Header	Disabled
Data Rate	
Data Rate	See Note 1
Auto Rate	Disabled
Note 1 The bandwidth utilized by DAS on the GDIS is controlled by the NCCDS manager.	

4.6.1.3.2. Output Ports

The WSGT GDIS output ports specified in Table 4-25, OTU-6A and OTU-6B, shall be configured as specified in Table 4-27. The parameters are defined in the GDIS Operations Manual, LOR-TR2387.

Table 4-27: WSGT GDIS Output Port Configuration

Parameter	Value
Channel Parameters	
Enabled	Enabled
Block Mode	Disabled
Local Control	Disabled
PN Test	Disabled
Invert Data	Disabled
Invert Clock	Disabled
Reverse Clock	Disabled
Clock Clamp	Disabled
Clock Tracking	Disabled
CAB Enable	Disabled
Data Rate	
Data Rate	See Note 1
Auto Rate	Disabled
Note 1 The bandwidth utilized by DAS on the GDIS is controlled by the NCCDS manager.	

4.6.2 GRGT GDIS-DAS Interface

4.6.2.1 Point of Demarcation

The point of demarcation between DAS and GDIS at GRGT shall be at the patch panels located in rack 1446.

4.6.2.2 Physical Interface

a. DAS shall interface with the GDIS via an RS-422/449 interface.
b. The DAS router shall be configured as a DTE device and the GDIS configured as the DCE device.
c. DAS shall provide interface cables with male three-lug TRB style connectors.
d. The signal names, directions and connector locations shall be as specified in Table 4-28.

4.6.2.3 GRGT GDIS Port Configuration

4.6.2.3.1 Input Port

The GRGT GDIS input port specified in Table 4-28, ITU-6A, shall be configured as specified in Table 4-29. The parameters are defined in the GDIS Operations Manual, LOR-TR2387.

Table 4-28: GRGT GDIS to DAS Interface

	RS-449 Signal Name	Direction	GRGT GDIS Port	Connector
a.	RD	GDIS → DAS	OTU-4A	1446-A9J31
b.	RT	GDIS → DAS	OTU-4A	1446-A9J32
c.	ST	GDIS → DAS	OTU-4B	1446-A10J32
d.	SD	GDIS ← DAS	ITU-6A	1446-A1J11
e.	TT	GDIS ← DAS	ITU-6A	1446-A1J12

Table 4-29: GRGT GDIS Input Port Configuration

Parameter	Value
Channel	
Enabled	Enabled
Block Mode	Disabled
Local Control	Disabled
PN Test	Disabled
Invert Data	Disabled
Invert Clock	Disabled
Reverse Clock	Disabled
Time Out	Disabled
Time Tag	Disabled
Modify Header	Disabled
Data Rate	
Data Rate	See Note 1
Auto Rate	Disabled
Note 1 The bandwidth utilized by DAS on the GDIS is controlled by the NCCDS manager.	

4.6.2.3.2 Output Ports

The GRGT GDIS output ports specified in Table 4-28, OTU-4A and OTU-4B, shall be configured as specified in Table 4-30. The parameters are defined in the GDIS Operations Manual, LOR-TR2387.

4.7 WSC Power to DAS Interface

4.7.1 Point of Demarcation

The point of demarcation between DAS and the WSC power equipment shall be at the under-floor power raceway.

Table 4-30: GRGT GDIS Output Port Configuration

Parameter	Value
Channel Parameters	
Enabled	Enabled
Block Mode	Disabled
Local Control	Disabled
PN Test	Disabled
Invert Data	Disabled
Invert Clock	Disabled
Reverse Clock	Disabled
Clock Clamp	Disabled
Clock Tracking	Disabled
CAB Enable	Disabled
Data Rate	
Data Rate	See Note 1
Auto Rate	Disabled
Note 1 The bandwidth utilized by DAS on the GDIS is controlled by the NCCDS manager.	

Table 4-31: Power Circuits at WSGT

	Rack #	Amps	Quantity	Connector
a.	7153	20	2	NEMA L5-20P
b.	7154	20	1	NEMA L5-20P
c.	7155	20	1	NEMA L5-20P

4.7.2 Circuits and Sizing and Connectors

4.7.2.1 WSGT

a. The number of circuits at WSGT shall be as cited in Table 4-31.

b. The size of circuits at WSGT shall be as cited in Table 4-31.

4.7.2.2 GRGT

a. The number of circuits at GRGT shall be as cited in Table 4-32.

b. The size of circuits at GRGT shall be as cited in Table 4-32.

Table 4-32: Power Circuits at GRGT

	Rack #	Amps	Quantity	Connector
a.	7160	20	2	NEMA L5-20P
b.	7161	20	1	NEMA L5-20P
c.	7162	20	1	NEMA L5-20P

4.7.3 Characteristics

The characteristics of the power provided shall be as cited in Table 4-33.

Table 4-33: Power Characteristics

	Parameter	Value
a.	Voltage, Steady State	115 v ± 5%
b.	Frequency, Steady State	60 Hz ± 3%

4.7.4 Circuits Breakers

For all circuits provided to DAS, the corresponding circuit breakers shall be part of WSC.

APPENDIX A: ADPE TO ECON SV INTERFACE

For information purposes only, Appendix A provides the interface description between the ECON and the EXEC ADPE.

A.1 Point of Demarcation

The points of demarcation between the EXEC ADPE and the ECON are defined in Table A-1.

Table A-1: Point of Demarcation

DEC Physical Port	P2
DEC Logical Port	TXA2
Connector designator	A9J2

The rack designators are given in Table A-2 for the EXEC ADPE's to which DAS will interface.

Table A-2: Points of Demarcation – Racks

SGLT and A/B	Rack
1A	3190S
1B	3193S
2A	3040S
2B	3043S
4A	3190W
4B	3193W
5A	3040W
5B	3043W
6A	3540G
6B	3543G

A.2 EXEC ADPE to ECON Message Format

The format of the TDRS state vector is defined in Table A-3.

Table A-3: State Vector Message Format

Byte Order	Bits	Type	Range	Description
1-2	15:0	ASCII	‘SV’	Start of Frame Marker
3-4	15:0	Unsigned 16-bit	[1300, 1309]	SIC
5	7:0	Unsigned 8-bit	[1]	VIC
6		ASCII	‘ ’	Spare
				Epoch:
7-8	15:0	Unsigned 16-bit	[0,65535]	Year
9-10	15:0	Unsigned 16-bit	[1,366]	Day of Year
11-12	14:0	Unsigned 16-bit	[0,23]	Hour of Day
13-14	15:00	Unsigned 16-bit	[0,59]	Minutes of Hour
15-16	15:0	Unsigned 16-bit	[0,59]	Seconds of Minute
17-18	15:0	Unsigned 16-bit	[0,999]	Milliseconds of Second
19		ASCII	’ ’	spare
20		ASCII	’ ’	spare
				Position Components:
21-24	31:0	Signed 32-bit	[-2^31,2^31-1]	X
25-28	31:0	Signed 32-bit	[-2^31,2^31-1]	Y
29-32	31:0	Signed 32-bit	[-2^31,2^31-1]	Z
				Velocity Components:
33-36	31:00	Signed 32-bit	[-2^31,2^31-1]	X
37-40	31:00	Signed 32-bit	[-2^31,2^31-1]	Y
41-44	31:00	Signed 32-bit	[-2^31,2^31-1]	Z
45	7:0	Unsigned 8-bit	[1,8]	Vector Type
46		ASCII	‘ ’	Spare
47		ASCII	‘ ’	Spare
48	7:0	ASCII	‘$’	End of Frame Marker

A.2.1 Data Field Description

a. Message Leader. Bytes 1-2 denote the beginning of the message block.

b. Support Identification Code (SIC). The contents of this field (bytes 3-4) is the SIC, or the SIC of the TDRS SV.

NASA has defined a unique SIC for each TDRS as follows:

TDRS-A: 1300
TDRS-C: 1302
TDRS-D: 1303
.
.
.
TDRS-J: 1309

c. Vehicle Identification Code (VIC). The content of this field (byte 5) is the VIC, or the VIC of the TDRS SV. The VIC for all TDRS's is 01.

d. Epoch Time. The contents of these fields (bytes 7-18) contain the epoch time of the SV, given as year, day of year, hours of day, minutes of hour, seconds of minute, and milliseconds of second.

e. Position Components. The content of these fields (bytes 21-32) is the X, Y, and Z components, respectively, of position in meters resolved to one meter

f. Velocity Components. The contents of these fields (bytes 33-44) is the X, Y, and Z components, respectively, of velocity in meters per second resolved to one thousandth meter/second

g. Vector Type. The contents of this field (byte 45) will be the vector type and are as follows:

1= Free Flight*
2= Transition to Free Flight
3= Not Used
4= Ignition
5= Burnout
6= Re-entry
7= Launch or on-orbit
8= Stationary

*TDRS vectors are always Free Flight vector type.

h. End of Frame (EOF) Marker. Byte 48 is the end of frame marker.

Notes:

a) Integer number format: All integer numbers greater than one byte in length, will be represented using "little-endian" format, with the least significant bytes stored in lower memory addresses, and transmitted first. All signed integers will be represented using two's complement format.

b) Spare bytes: Spare bytes are included for word alignment of message fields, or for possible future use. All spare byte fields will be set to ASCII blank, ' '.

A.3 Protocol

The following protocol is used:

Data bits:	8 bits
Parity:	No parity
Stop Bits:	1 stop bit
Flow control:	XON/XOFF
Baud Rate:	115k baud rate.

At each end of the interface loop back pins 4 "Request to Send" (RTS) to 5 "Clear to Send" (CTS) and 6 "Data Set Ready" (DSR), 8 "Received Line Signal Detector (Carrier Detect)" (DCD), and 20 "Data Terminal Ready" (DTR).

A.4 Coordinate System Frame of Reference

The coordinate frame of reference is Greenwich True-of-Date Rotating Coordinate System as defined in ICD between the NCC, FDF, and WSC, 530-ICD-NCC-FDF/WSC, Figure 9-1. Vectors expressed in this system are relative to a rotating reference frame fixed to the earth, whose rotation rates are expressed relative to the mean equator and equinox of the J2000.0 system.

A.5 SV Message Frequency

For each TDRS SV transmission received at the EXEC ADPE, a single TDRS SV will be provided to DAS, for the TDRS assigned to the EXEC ADPE. From each of these transmissions, the first vector, which has the earliest epoch time, will be selected and then downloaded to the DAS without operator intervention. In general, the epoch of this vector will be several hours in the future at the time of its transmission. Vectors are transmitted from the NCC to WSC once every 24 hours, but additional transmissions may occur under certain circumstances. The TDRSS Operations Control Center (TOCC) operator may also retransmit TDRS SV's to an EXEC ADPE at any time.

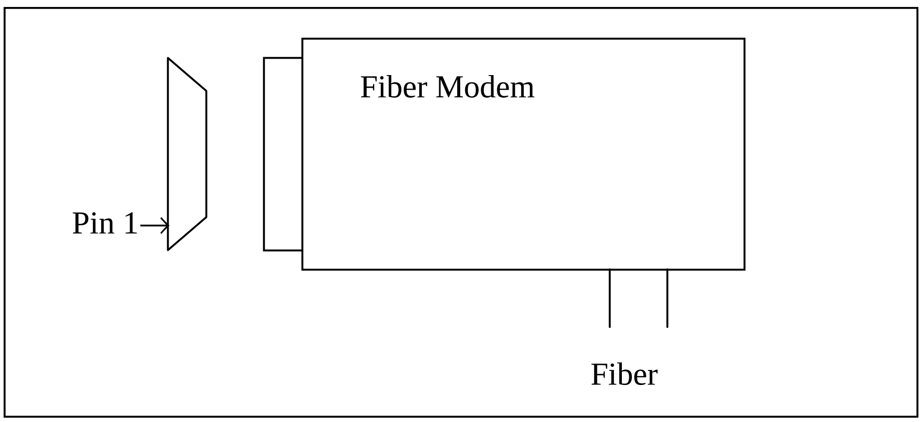
For ECON initialization purposes, the TOCC operator may select a TDRS vector from the EXEC ephemeris database for an auxiliary transmission to ECON. This auxiliary transmission may utilize any epoch among the TDRS vectors available in the EXEC ephemeris database. In addition, this transmission may be for any TDRS, in the event that a TDRS is not yet assigned to the SGLT, or to prepare for a change in TDRS assignments.

A.6 Physical/Electrical Interface

The interface between the EXEC ADPE and the ECON is a RS-232 interface with a DB25M connector being provided on the ADPE. The ADPE is configured as a DTE device.

Due to the distance between the EXEC ADPE's and the DAS equipment, a RS-232 fiber extender is required for each interface. Due to space limitations inside the ADPE cabinet, the fiber cables leaving a fiber modem, connected directly to the serial port, exit the bottom of the modem. The DB25 connectors are installed with pin 1 to the bottom left of the connector, as shown in Figure A-1.

Figure A-1: ADPE Fiber Modem Connection



Abbreviations and Acronyms

ADPE	Automated Data Processing Equipment
ADQS	Analog/Digital Quad Splitter
BIT	Built-in Test
CCB	Configuration Control Board
CDB	Common Data Broadcast
CP	Control Processor
CRC	Cyclic Redundancy Check
CTFS	Common Timing and Frequency System
CTS	Clear to Send
DAP	Demand Access Processor
DAS	Demand Access System
DASCON	DAS Controller
dBm	Decibels referenced to one milliwatt
dBc	Decibels referenced to carrier
DCD	Received Line Signal Detector (Carrier Detect)
DCN	Document Change Notice
DIS	Data Interface System
DSR	Data Set Ready
DTR	Data Terminal Ready
ECON	EMC Controller
EDS	EMC Distribution System
ELD	MA Element Data
EMC	Element Multiplexer Correlator
EOF	End of Frame
EXEC	Executive
FC	Fibre Channel
FDF	Flight Dynamics Facility
FPD	Front Panel Display
Gbps	Gigabits per second
GDIS	GRGT Data Interface System
GMT	Greenwich Mean Time
GRGT	Guam Remote Ground Terminal
GSFC	Goddard Space Flight Center
HDLC	High-Level Data Link Control
Hz	Hertz
IBU	Independent Beamforming Unit
ICD	Interface Control Document
IEEE	Institute of Electrical and Electronics Engineers
IF	Intermediate Frequency
IFL	Interfacility Link
IIRV	Improved Interrange Vector
IOnet	Internet Protocol Operational Network
IP	Internet Protocol
IRIG	Inter-Range Instrumentation Group
KHz	Kilohertz

LCM	Local Control Monitor
LSB	Least Significant Bit
MA	Multiple Access
MABE	Multiple Access Beamforming Equipment
MHz	Megahertz
MSB	Most Significant Bit
msec	millisecond
Msps	Megasymbols per second
NASA	National Aeronautics and Space Administration
NCC	Network Control Center
NISN	NASA Integrated Services Network
NTS	Network Transparent Switch
PCI	Peripheral Component Interconnect
PMC	PCI Mezanine Card
pps	pulse per sec
RD	Receive Data
RF	Radio Frequency
RMS	Root Mean Squared
RT	Receive Timing
RTS	Request to Send
SD	Send Data
SGLT	Space-to-Ground Link Terminal
SN	Space Network
SOF	Start of Frame
SSC	Subsystem Controller
ST	Send Timing
STGT	Second TDRSS Ground Terminal
SV	State Vector
SWSI	SN Web Services Interface
TBD	To Be Determined
TBR	To Be Resolved
TCP/IP	Transmission Control Protocol/Internet Protocol
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TGBFS	Third Generation Beamforming Subsystem
TOCC	TDRSS Operations Control Center
TT	Transmit Timing
UDP/IP	User Datagram Protocol/ Internet Protocol
USNO	United States Naval Observatory
UTC	Universal Time Coordinated
VIC	Vehicle Identification Code
Vrms	Root Mean Square Voltage
WSC	White Sands Complex
WSGT	White Sands Ground Terminal